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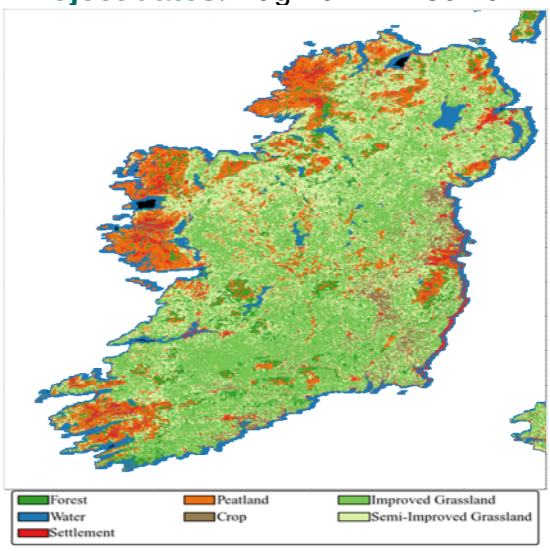
ILMO: Irish Land Mapping Observatory



Key external stakeholders:
Government, EPA, Planners, DAFM

Practical implications for stakeholders:
This work forms part of the methodological infrastructure required for a national land cover mapping system. A rigorous, correct and repeatable method for mapping landcover in the State is a basic requirement for the implementation and evaluation of many policies, e.g. GHG reporting

Main results:

- An accurate method of repeatedly mapping Irish grasslands and other land covers at field scale has been established.
- New sources of RADAR remote sensing have been used to distinguish between improved and semi improved, dry and wet grasslands with draft maps for Counties Longford and Sligo published with accuracies of 91-96%.
- Large scale mapping of landcover nationally at 250m was achieved using optical satellite systems with 95% accuracy.
- Practical limitations on accuracies due to shadow (e.g. from hedgerows) and field size were established.
- Carbon stock changes associated with land cover change between improved, semi-improved grassland and scrub sub-categories within the grassland category were calculated between 1992 and 2008 transitions. This showed a large sink (sequestration) of CO2, equivalent to 0.3 to 1t CO_2 per ha per year.
- OSI Prime 2 mapping is established as basis for national land cover mapping program.

Opportunity / Benefit:

- Grassland types have been distinguished using remote sensing. This is important for agronomic and environmental applications of a national landcover map
- RADAR imagery has been shown to successfully map grassland types. This is valuable as RADAR systems are not obscured by cloud and therefore map outputs are guaranteed when needed.
- Proposals for a national system of land cover mapping are in train based on the methodologies presented here.
- The benefit in accurately reporting within class (grassland) changes for accurate reporting of GHG sequestration has been demonstrated.

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1. Project background:

Within Ireland there is ongoing discussion regarding how to map land use, land cover, and changes to those landscape elements in an objective and repeatable manner. This is driven by the need to provide spatial data on land use and cover for planning, and policy creation and implementation. A particular driver is the need for land use change monitoring for accurate inventories of GHG budgets. Ireland participates in the EU-wide mapping project CORINE; this has been shown to be inadequate for many national and local scale applications.

The Irish Land Mapping Observatory (ILMO) project is one of a number of projects Teagasc is involved in to establish the practical methodology for producing a national land cover map that can be generated on an annual basis, drawing primarily on satellite imagery supplemented by ancillary field data, to populate the Ordnance Survey Ireland PRIME2 map database.

For the purposes of this project, Counties Longford and Sligo (where early drafts of the Prime 2 maps were available) were used to test different methodologies and the utility of the outputs for mapping GHG inventories.

2. Questions addressed by the project:

- Can Irish agricultural grasslands be classified at a higher thematic precision than just “grass”?
- What are the GHG inventory implications of monitoring change within landcover classes?
- Can the OSI Prime 2 map be used as the basis for a national land cover map?

3. The experimental studies:

Satellite images have long been used to discriminate ground features on the basis of their spectral reflectance, but to take the dynamics of the Irish vegetation into account several images per year are required. To achieve this in a frequently cloud covered country, 16-day composite MODIS vegetation index images were used to separate elements on the basis of their phenological cycle. MODIS is an optical sensor system flown on NASA’s Terra and Aqua satellites. It takes an image of Ireland every other day- composite imagery is a way of overcoming cloud cover by taking the cloud free sections of each image in the 16 day period and stitching together to get one cloud free image for the period.

These images were then classified into landcover (Forest, Water, Settlement, Peat Bog, Improved Grass and Semi-improved Grass). While classification using machine learning methods proved to be very successful for homogenous regions, the Irish landscape is highly fragmented and in both Longford and Sligo, problems were encountered with multiple land covers within the 250x250m pixels (approximately 6 Ha). A draft national map was produced to demonstrate scalability of the process.

A number of approaches were explored to derive the sub-pixel content of the images (to estimate the relative component of each land cover within a pixel) but illumination and geo-location instabilities, contributed a significant error component to the time series. It thus appears that sub-pixel methodologies for land cover mapping in Ireland using currently available medium (250x250m or coarser) resolution data are not possible.

To overcome these data acquisition limitations imposed on optical data by cloud cover, the value of synthetic aperture radar (SAR) imagery for land cover classification was also investigated. The temporal frequency of acquisitions is lower than for MODIS and only one wavelength is available but the 20m spatial resolution of ASAR and PALSAR data is far superior and imagery is reliably available as RADAR systems see through cloud. Machine learning algorithms were used to successfully classify the SAR imagery (this time introducing an extra level of classification for grassland; wet and dry). The RADAR derived maps with their higher resolution was used to populate the Prime 2 database. Maps for 2008 and 1992 were produced for Sligo and Longford.

These Prime 2 landcover maps were used to estimate greenhouse gas emission/reduction profiles for crop and grasslands. Methods were developed to estimate carbon stock changes for land management and land cover and use transitions based on existing methodologies and newly published biomass and soil organic carbon (SOC) activity data.

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4. Main results:

Low resolution MODIS optical data (250m) are valuable for regional scale land cover mapping, but not at the field level where inter and intra-annual variations cannot be reliably determined. Time series data can be used to show seasonal changes in the phenology of homogenous areas (>250m^2) of vegetation in Ireland. The MODIS 250m resolution maps had an overall accuracy of 95%. Analysis of time series trends show that the landcover classes are most easily distinguished from one another in April.
Implication of this?
Small fields continue to present an insurmountable problem in resolving sub-pixel land-cover signals from coarse resolution satellite data due to inherent noise and geo-location issues. It is likely that the compound effect of shadow in land cover studies from landscape elements such has hedgerows have been under estimated.
PRIME2 map units are suitable for mapping land cover.
Improved, semi-improved, wet and dry grasslands can be distinguished over large heterogeneous areas using a synergy of SAR and ancillary data. The Sligo map has an overall accuracy at 20m resolution of 91% and the Longford map of 96%.
Net emissions from croplands in the two study areas, over the period 1992 to 2008, were primarily associated with a loss of soil organic carbon following conversion of grasslands to cropland.
Transitions between improved grassland, semi-improved grassland and scrub sub-categories within the remaining grassland category resulted in a large sink (sequestration) of CO_2, equivalent to 0.3 to 1 t CO_2 per ha. per year.

5. Opportunity/Benefit:

It is now possible map, at a spatial high resolution and accuracy, different grassland types (Improved, Semi-improved, Wet and Dry). The use of RADAR data means that it is possible to reliably and dependably up-date the map every year. This points toward accurate accounting of GHG flows from land management within the dominant “grass land” landcover in Ireland.

6. Dissemination:

Cawkwell, F., Barrett, B., Nitze, I., Green, S., Black, K., & Hallahan, P. (2014). The Irish Land Mapping Observatory (ILMO) Mapping and Monitoring Land Cover, Use and Change. 2011-CCRP-MS1.4 CCRP Report EPA Climate Change Research Programme 2007-2013. Dublin: EPA.
Barrett, B., Nitze, I., Green, S., & Cawkwell, F. (2014). Assessment of multi-temporal, multi-sensor radar and ancillary spatial data for grasslands monitoring in Ireland using machine learning approaches. Remote sensing of environment, 152(September 2014), 109-124

Barrett, B., Nitze, I., Cawkwell, F., Green, S. (2014) Assessment of multi-temporal, multi-frequency radar and ancillary spatial data for routine grassland monitoring. Frontiers in Earth Observation for Land System Science (A joint workshop of the EARSeL SIG LULC and the NASA LCLUC Science Team), Humboldt-Universität zu Berlin, Berlin, Germany , 17th Mar 2014 – 18th Mar 2014

Nitze, I., Barrett, B., Green, S., Cawkwell, F. (2014) Inventory assessment of grassland in Ireland using hyper-temporal optical data. Frontiers in Earth Observation for Land System Science (A joint workshop of the EARSeL SIG LULC and the NASA LCLUC Science Team), Humboldt-Universität zu Berlin, Berlin, Germany , 17th Mar 2014 – 18th Mar 2014.

Barrett, B; Nitze, I; Green, S; Cawkwell, F (2013) Contribution of multi-temporal and multi-frequency radar data to operational grassland mapping. 7th Irish Earth Observation Symposium, Teagasc, Ashtown, Dublin, Ireland, 24th Oct 2013 – 25th Oct 2013.

Nitze, I; Barrett, B; Cawkwell, F; Green, S (2013) Comparison of DMC and Landsat data for the classification of grassland use. 7th Irish Earth Observation Symposium, Teagasc, Ashtown, Dublin, Ireland , 24th Oct 2013 – 25th Oct 2013.

Nitze, I; Barrett, B; Cawkwell, F; Green, S (2013) An automated processing chain of large-scale hyper-temporal optical data for machine-learning based classification. 7th Irish Earth Observation Symposium,

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Teagasc, Ashtown, Dublin, Ireland, 24th Oct 2013 – 25th Oct 2013.

Barrett, B., Nitze, I., Cawkwell, F., Green, S. (2013) Improving grassland inventories in Ireland – the contribution of multi-temporal radar data. Remote Sensing and Photogrammetry Society (RSPSoc), Glasgow, Scotland, 04th Sep 2013 – 06th-Sep 2013.

Nitze, I., Barrett, B., Cawkwell, F., Green, S. (2013) Inventory assessment of grasslands in Ireland using hyper-temporal optical data. Remote Sensing and Photogrammetry Society (RSPSoc), Glasgow, Scotland, 04th Sep 2013 – 06th-Sep 2013.

Barrett, B., Nitze, I., Cawkwell, F., Green, S., Hallahan, P., Black, K. (2013) Improving Grassland Inventories in Ireland - the Contribution of Multi-Temporal SAR data. European Space Agency (ESA) Living Planet Symposium, Edinburgh, Scotland, 09th Sep 2013 – 13th Sep 2013.

Nitze, I., Barrett. B., Cawkwell, F., Green, S., Hallahan, P. (2013) Inventory Assessment Of Grasslands In Ireland Using Hyper-Temporal Optical Data. European Space Agency (ESA) Living Planet Symposium, Edinburgh, Scotland, 09th Sep 2013 – 13th Sep 2013.

Cawkwell, F., Barrett, B., Nitze, I., Green, S., Dwyer, N. (2012) Irish Land Mapping Observatory (ILMO). Remote Sensing and Photogrammetry Society (RSPSoc), University of Greenwich, London, UK , 12th Sep 2012 -14th Sep 2012.

https://landmapping.wordpress.com/ilmo/

7. **Compiled by**: Stuart Green

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